

# Clustering as a Factor of High-Tech Development of the Economy: an Evolutionary Approach

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**Abstract**—The article examines the evolutionary stages of the functioning of the economic cluster. The main distinction between cycles of evolution of a cluster structure is a complex representation and the characteristics of the cluster system in the context of the organizational interaction between the residents of the cluster, which can serve as a factor in the choice of the strategy for implementing the cluster policy of high-tech economic development and measures of managerial influence and support from the state and commercial structures.

**Keywords**—cluster, cluster structure, development stages, growth factors, high-tech development, innovations, competitive advantages.

## I. ECONOMICS AND PRODUCTION

Cluster technologies in the modern economy are a direction for the formation of competitive business advantages in the spatial structure of the national economy of the region and the country as a whole. The protection of clusterization and cluster development for harmonious convergence in the economy should be based on a systematic understanding of the functioning of cluster structures as an object of effective management from the startup phase and the initial clustering (proto-cluster) to subsequent periods of the life cycle of the cluster formation. The scientific basis of the practical aspect of cluster policy should form the concept of cluster structures which are integral systems.

The aim of the study is to describe the cluster from the point of view of the life cycle stages based on their characteristic evolutionary features affecting the driving forces and vectors of the transformations that are taking place. These research results can be used as a scientific justification for the implementation of cluster policy from the standpoint of the evolutionary approach in the overall concept of high-tech development of the economic space.

## II. MATERIALS AND METHODS

Theoretical and methodological basis of the research was focused on scientific concepts and scientific results of foreign and national scientists was devoted to cluster theory and clustering. In the process of research, general scientific methods of cognition (dialectics, systems approach, comparative analysis, complex and cluster approach) were used.

## III. RESULTS AND DISCUSSION

The process of cluster evolution implies certain stages of the life cycle that characterize the transformational changes in cluster education. Clusters are characterized by signs that identify and analyze them as self-organized socio-economic systems.

Such clusters are inherent in: development which can consist in increasing the complexity of the system (in the cluster, this may be the inclusion of new industries in economic relations, the growth of internal connectivity of the cluster); improvement of adaptability to external conditions (improvement of the cluster product in accordance with changes in consumer preferences); increase in the scale of the phenomenon (growth of clusters in width and depth); quantitative growth of the economy and qualitative improvement of its structure (increase in productivity of cluster enterprises and production scales in the cluster, growth of cluster external connectivity); social progress (employment growth in the region, wage increases and other social effects as a result of economic growth) [11,75].

The evolutionary development of a cluster implies transformational changes in its states, which can be characterized as the life cycle of a cluster structure - from the formation of the needs for the transformation in cluster of education until the moment of the reduction of the efficiency (total suppression) of functioning and the subsequent decay of the system leading to its leveling (reorganization, liquidation, etc.). Changes in the system in the aggregate with existing

internal connections allow us to assess the positive and negative aspects of the functioning of the cluster structure (system).

As noted by Kleiner G. B., Kachalov R. M. and Nagrudnaya N. B., the choice of the strategic direction of his subsequent evolution depends on the stage of the life cycle in which the cluster is located [9]. In turn, Tarasenko V.V. notes the correlation dependence of the toolkit and methodological approaches in the management strategy on the life cycle of the cluster in which he is located himself.

Stages of the life cycle of the cluster structure are devoted to a large number of scientific papers. In the works of Record S.I. [16] and Frolov A.V. [7], an approach to describing the life cycle of a cluster based on analogy was applied. Its base is formed on the parallels of the evolution of the cluster with the life cycle of the commodity, the company, the industry which can be expressed as an «anthropological» principle from birth to death but with the variation of the subsequent recreation under certain conditions that contribute to the functioning of this system. In principle, we distinguish the following stages: the stage of origin, the formation, the development (growth) and the degradation (decay, disappearance or transformation).

It is assumed that Markov L.S., Yagolnitzer M.A. [13] and Boush G.D. [4], used a more adjusted approach, based on the stages of the life cycle, taking into account the cluster characteristics.

1. The cluster as a system of self-organizing format capable of spontaneous formation in the economic environment with a certain time interval being unidentifiable including both for residents of the cluster configuration and for external participants;

2. Clusters arise on a cluster of enterprises which initially may not contain the features of the cluster structure (agglomeration). Stages of the life cycle of the cluster should be considered from the point of view of various characteristics (participants, connections, boundaries, external environment).

#### A. The 1st Stage - Agglomeration

The first stage focusing is characterized as a stage of local-point concentration of residents (enterprises) of the cluster serving and related industries. The localization of enterprises in a certain territory is the first sign that indicates the possibility of creating a cluster for future competitive interaction. At the same time, this concentration becomes a source of generation of inter-subjective technological chains, including those that did not exist before. The existing technological and organizational links between the integrated structures can become a catalyst for productivity growth and competitive advantages. According to Weber A., agglomeration is a cluster of enterprises within the framework of which there is a cost saving due to the scale of production and specialization [22, 23]. This moment can be a trigger point in the evolutionary formation of the cluster structure.

The structural transition from the first to the second stage predetermines a certain cluster initiative. Tarasenko V.V. describes it as the actions of organizations and/or their groups aimed at transforming existing industrial agglomerations in a

cluster in conditions of their insufficient formation [21]. Cluster initiatives are the result of increasing the organizational component of the existing agglomeration.

#### B. The 2nd Stage - Formation (Cluster Project)

The stage is characterized by the emergence of more intense competition which leads to the need to search for new directions and forms of competitive relationships. This need is realized at the expense of innovative start-ups in the chain of meeting the demand of consumers including due to the existing experience of cooperation of enterprises in the configuration of vertical and/or horizontal links. The differentiation of companies takes place under the needs of the cluster structure (companies «focus» of the cluster - companies «anchor» or so known companies, competitive); the qualitative indicators of raw materials are growing efficiency of using technologies and equipment, services to a specialized orientation of growth of demand for highly qualified personnel. It is necessary to note the development of interpersonal contacts in the cluster and business environment, inter-firm cooperation.

#### C. The 3rd Stage – Evolutionary Functioning

Competition grows noticeably based on equipments, technologies, raw materials, qualified personnel marketing development. Stage can be identified by the presence of certain cluster effects, for examples, savings and comprehensive benefits from participating in the cluster configuration. Formal and informal institutions are formed up to ensure the maintenance and development of mutually beneficial cooperation. This stage is characterized by certain dynamics in the form of new residents in the cluster structure, since the barriers to join (exit) the cluster are significantly lower in the overall concept of the attractiveness of the complex of emergence and synergy of the cluster enterprises. The involvement of new industries and enterprises that will form a vertical chain of integration links or already have horizontal links with the residents of the cluster can serve as a driver of development. Personal relations in the form of mutually beneficial channels of transfer of knowledge, information, technology and innovation, as well as subjective interest in competitive cooperation between the enterprises of the cluster contribute to a certain extent. We note the strategic need for regional cluster policy as a factor in the development of cluster structures. The described set forms further consistent changes in the characteristics of the cluster formation: the growth of the cluster in depth and width, the achieved concentration of production capacity attracts the local market consumer demand by reducing costs and risk in commodity exchange operations. The cluster is approaching the threshold values of «critical mass», it acquires the properties of innovation (sensitivity and mobility to innovative startups). There is a further development and complication of interpersonal cooperation of cluster subjects. Cluster complicates its structure due to the growth in depth and width. Noncompetitive companies in competitive environment (natural process of competitive relations), leaves the cluster.

#### D. The 4th Stage – Mature (Realized) Cluster

Mature cluster can be described by bright cluster effects, high competitiveness and innovation, showing due to the achieved «critical mass», high values of vertical and horizontal

intra-cluster integration. It should be noted, high development degree of the final products market, raw materials market, market of technologies and equipment, labor and other. At a professionally effective level, the intra-cluster information transfer is carried out. A high degree of competition and cooperation in the cluster in synergy with the effects of social capital and social responsibility is still the driver of the cluster structure evolution. The role of regional cluster policy in the high-tech development of the territory's economy is also significant. At this stage, regulator (Moderator) of further development of the cluster can be identified. A certain effect is achieved through the perception of cluster subjects (enterprises) as residents of cluster formation. The cluster in the regional socio-economic policy is able to perform the role of «points of growth», especially in regions with mono profile enterprises, which contributes to the development of diversified high-tech productions and improve the standard of living in the region.

This process in the life cycle of the cluster can be characterized as fluctuations in its level of organization. Fluctuations in organization are based on the multidirectional impact of external and internal factors of the cluster structure, but are not irreversible and critical. They do not destroy the system of interaction of enterprises, but continuously transform them. In the market economy, the sources of these fluctuations are primarily the internal interests of the cluster members, which can both intersect and be multidirectional. A complex set of external factors also causes oscillatory processes in the level of cluster organization. At the same time, a special role in the economy is assigned to the government, which can, «as external regulator», actively influence the processes of transformation of the cluster structure through various organizational and economic mechanisms [6].

#### *E. Stage 5-Modification Transformation (Residual Interaction)*

It is possible to describe the destructive changes in the cluster members links, which leads to its reduction. Objective reasons for such processes could be changes in the external environmental contour - variations in commodity and raw materials markets, the labor market, technology and equipment, information exchange flows. Thus, the cluster is subject to transformational changes (degradation, disintegration).

At this stage of its transformation, the cluster exists in the state of «Museum», having no effects in the competitiveness and innovative development of the economic complex of the territory [19]. Cluster members lose their competitive advantages, although can still continue functioning based on the most stable relationships of key residents. The final stage of the cluster collapse can take the form of formalized leveling cluster configuration as for inexpedient city government support of the entire cluster structure. Disintegrated clusters may become integrational parts of other clusters, if any functioning in this territory.

#### IV. CONCLUSIONS

Measures to support cluster structures should be based on a system of representations of clusters as an object of management activities, on the principles of multidimensionality

and supplemented in synthesis with institutional and political economic approaches. The choice of goals and tools of cluster policy depends on the degree of cluster development. In the process of evolution, each stage is characterized by certain specific characteristics of a certain state achieved in the process of development in convergence with the driving forces and directions of change.

Mature cluster is represented by qualities in the most pronounced form and intensity of cluster properties and features that are revealed in cluster effects, high degree of innovation and competitiveness. Matured cluster is characterized by a high degree of competitive advantages of the cluster product, the market of final cluster products, effective production factors and mechanisms of information and technological transfer. The driving forces include a high degree of competition and cooperation on the platform of social capital. The Manager (regulator) of a mature cluster is an element of positive evolutionary transformations in the cluster, which, in turn, is able to carry out the mission of «points of growth» of the territory, contributing to the improvement of welfare and living standards.

In order to eliminate the threat of degradation of the cluster at the stage of formation of cluster structures (cluster project), it is necessary to develop and consistently implement at all stages measures to prevent the destructive processes of cluster configuration changes – diversification of production, expansion of market segment of the final cluster product and services, verification, rotation and extension of the range of cluster residents.

Understanding the structure of the cluster (connections, composition), the dynamics of changes and factors affecting them are necessary for the formation of cluster policy and strategy for its implementation. The initial step should be the identification of the stage in which the cluster is located, the characteristics describing its state and the driving factors. On this basis, it is necessary to select the tools of cluster policy, including measures to support the regulated cluster, which is a necessary condition for the effective choice of the strategy of cluster development of the territory.

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